Searching for Jacobi shapes in rapidly rotating nuclei

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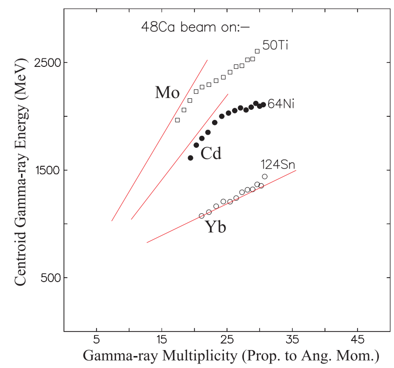
We are studying the inertia of nuclei rotating at the highest attainable angular momenta to investigate whether highly deformed (Jacobi) shapes predicted to occur for a very general class of objects at sufficiently high angular momentum also occur in atomic nuclei. Recent calculations refining the concepts given in [1] show that nuclei over a broad region of the periodic table (50<A<130) may exhibit the Jacobi transition at experimentally attainable spins. However, the role of shell-corrections to the liquid- drop model calculations is not clear.

The table summarizes the experimental conditions. Experiments were performed at the 88" Cyclotron with the 8PI Spectrometer. Discrete gamma-ray transitions are not expected at the spins and excitation energies relevant to these studies; rather we must examine the "continuous" gamma-radiation. With the 8PI Spectrometer it is possible to select spectra in the (Compton suppressed) HPGe-detectors according to the number of gamma-ray hits observed in the 72-element BGO Ball, which functions both as a sum-energy and multiplicity spectrometer.

TARGET	^{50}Ti	^{64}Ni	^{124}Sn
^{a}Beam E (MeV)	215	195	215
^{a}Beam L_{max} ($\hbar$)	72	70	<70
L_{Jacobi} ($\hbar$)	57	65	fission
$\Im^{(1)}$ ($\hbar^2$/MeV) at High L			
Experiment	41	54	75
Liquid Drop	28	35	70
Typical SD band	34	43	90

^{a} A ^{48}Ca beam was used in all cases.

To isolate the interesting gamma rays we subtract suitably normalized HPGe-spectra that are "gated" by successively higher folds (or hits) in the BGO ball: ie. (K+1)-(K), K is the number of hits. Intuitively this should select the spectrum of transitions at the very top of the gamma-ray cascade - detailed simulations confirm this expectation. The resultant increase in the energy (centroid) in the continuous γ-ray spectrum is plotted as a function of multiplicity (M) in the figure, where M (the "real" number of gammas) is derived from the observed number, K.



The signature of a Jacobi-transition is that the system reaches a maximum rotational frequency ($\hbar\omega$) with increasing angular momentum. For collective rotation in the nuclear case $\hbar\omega = E_\gamma/2$, therefore, a signature will be a maximum in gamma-ray energy with increasing spin. Although we have not seen such a feature in the present experiments, the gamma-ray energy centroids for ^{98}Mo and ^{112}Cd compound systems show a very large and increasing deviation from the inertia of a rigid sphere or from the Thomas-Fermi model value (red lines), and at the highest spins are comparable with superdeformed values (see table).

We believe that the reactions studied here did not bring in enough angular momentum to reach the Jacobi transition, and we have experiments planned to remedy this, nevertheless the data show that the inertia of some nuclei increases much more rapidly than would be expected even at spins below the Jacobi point.

[1] *S.Cohen et al., Ann. Phys 82 (1974) 557.*